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Project Summary

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The Total Exposure Assessment Methodology (TEAM) Study

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This report documents all aspects of a study of personal exposures of 800 residents of seven U.S. cities to toxic and carcinogenic chemicals in their air and drinking water. In the four-volume Final Report, Volume I is an overview of the TEAM Study. Volume II deals with the results from 1981 to 1983 in New Jersey, North Carolina, and North Dakota; and Volume III with the results from 1984 in California. Volume IV is a compilation of Standard Operating Procedures (SOPs) developed for the TEAM Study by the prime contractor—Research Triangle Institute. These SOPs may be applicable to similar studies of human exposure to volatile organic compounds.

This Project Summary was developed by EPA's Office of Acid Deposition, Environmental Monitoring and Quality Assurance, Washington, DC, to announce key findings of the research project that is fully documented in four separate volumes of the same title (see Project Report ordering information at back).

Introduction

The TEAM Study was planned in 1979 and completed in 1985 (Table 1). The goals of this study were: (1) to develop methods to measure individual total exposure and resulting body burden of toxic and carcinogenic organic chemicals; and (2) to apply these methods to estimate the exposures and body burdens of urban populations in several U.S. cities. To achieve these goals, the following approach was adopted:

1. A small personal sampler was developed to measure personal exposure to airborne toxic chemicals;
2. A specially-designed spirometer was developed to measure the same chemicals in exhaled breath;
3. A survey design involving a three-stage stratified probability selection approach was adopted to insure inclusion of potentially highly exposed groups.

A pilot study was conducted between July and December 1980 to test 30 sampling and analytical protocols for four groups of chemicals potentially present in air, water, food, house dust, blood, breath, urine, and human hair.

The results of the pilot study (1,2) indicated that the TEAM goals could be met at present for only one group of compounds: the volatile organics. Adequate methods existed to determine their concentrations in personal air, ambient air, exhaled breath, and drinking water. They were not present in food (with the exception of chloroform in beverages), so that food could safely be ignored.

The main TEAM Study measured the personal exposures of 591 people to a number of toxic or carcinogenic chemicals in air and drinking water (Table 2). The subjects were selected to represent a total population of 717,000 residents of seven cities in New Jersey, North Carolina, North Dakota, and California. Each participant carried a personal air sampler throughout a normal 24-hour day, collecting a 12-hour daytime sample and a 12-hour overnight sample. Identical samplers were set up near some participants' homes to measure the ambient air. Each participant also col-

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lected two drinking water samples. At the end of the 24 hours, each participant contributed a sample of exhaled breath. All air, water, and breath samples were analyzed for 20 target chemicals (26 in California) (Table 3).

Quality of the Data

An extensive quality assurance (QA) program was carried out. About 30% of all samples were either blanks, spikes, or duplicates. Analysis of each medium (air, water, breath) was repeated for 10% of samples in external QA laboratories (IIT Research Institute and the University of Miami Medical School). Audits of all laboratory activities were undertaken by EPA's Environmental Monitoring Systems Laboratory at Research Triangle Park, North Carolina (EMSL-RTP), and spiked samples were supplied by EMSL-RTP (air) and EPA's Environmental Monitoring and Support Laboratory in Cincinnati (water). A separate QA report was written by an independent laboratory (Northrop Corporation) concluding that no significant analytical differences could be found among the three air monitoring laboratories (Research Triangle Institute, IIT Research Institute, and EMSL-RTP).

Results

Phase II (New Jersey, North Carolina, North Dakota)

In New Jersey, 11 of the 20 target chemicals were found to be prevalent (Table 4). In all cases, personal air values exceeded outdoor air values, by ratios of 2-5 (Figures 1 and 2). Breath concentrations also often exceeded outdoor air values (Figure 3). The highest indoor air concentrations exceeded the highest outdoor air concentrations by factors of 10-20 (Figure 4).

These indoor-outdoor differences were also observed in both repeat visits to New Jersey and the visits to Greensboro, North Carolina and Devils Lake, North Dakota. In all visits, the only target chemicals prevalent in drinking water were chloroform, bromodichloromethane, and dibromochloromethane (Table 5).

Breath levels were significantly correlated with previous daytime air exposures for 10 of 11 prevalent chemicals in the first New Jersey sampling trip (Fall 1981) (Table 6). The 11th chemical, chloroform, showed a significant correlation between breath and drinking water concentrations.

Table 1. Summary of TEAM Studies

Name and Description of Study	Time of Study	References	Ref. No.
1. *Lamar University – UNC Study*	*March 1980; June 1980*	*Wallace 1982a* *Zweidinger, 1982*	*1* *2*

Eleven college students at Lamar Univ. and six at UNC-Chapel Hill were studied to field-test the personal air monitors, the spirometer for collecting breath samples, and the analytical techniques for air, water, breath, blood, and urine. Large variations in exposure (2-3 orders of magnitude) were noted, as was a correlation between breath values and air exposures for some chemicals.

2. *TEAM Pilot Study—Phase I*	*July-Dec. 1980*	*Pellizzari, 1980, 1982*	*3,4*
		Entz, 1982	*5*
		Spersino, 1982a,b	*6,7*
		Wallace, 1982b,c; 1984a	*8,9* *10*

Nine persons in the Bayonne-Elizabeth area of New Jersey and three persons in the Research Triangle Park area of North Carolina were visited three times for three days at a time between July and December 1980. Seven consecutive 8-hour air samples were collected on each visit, as were food, house dust, drinking water, blood, urine, hair, and breath samples. Twenty-eight sampling and analytical protocols were tested for use in determining personal exposures and body burdens for four groups of chemicals: volatile organics, metals, pesticides and PCBs, and polyaromatic hydrocarbon (PAHs). It was concluded that only the volatile organics could successfully be included in a total exposure study. Problems with air and food sampling and analysis protocols prevented inclusion of metals and pesticides.

3. *TEAM Study—Phase II*	*Sept.-Feb. 1983*	*Pellizzari, 1981, 83, 1984a,b*	*11,12, 13,14*
		Hartwell, 1984	*15*
		Wallace, 1984b, 1985a, 1985b,c	*16,17, 18,19*
		Pellizzari, 1985a	*24*

350 persons in Bayonne and Elizabeth, New Jersey; 25 in Greensboro, North Carolina; and 25 in Devils Lake, North Dakota participated in this study which is described in Volume II of the full report and also in a number of journal articles.

4. *TEAM Study—Phase III*	*Feb.-June 1984*	*Pellizzari, 1985b,c*	*25,26*
		Wallace, 1985	*23*

200 persons in Los Angeles, Antioch, and Pittsburg, California participated in this study, which is described in Volume III of the full report.

5. *TEAM Study—Indoor Air*	*March 1982-June 1985*	*Pellizzari, 1984*	*22*
		Wallace, 1984c	*20*
		Sheldon, 1985a	*27*

Four commercial and public-access buildings were studied to test indoor air monitoring methods and to obtain an initial view of indoor air levels of volatile organics, inhalable particulates, pesticides, and metals. One new office building was visited when newly finished, one month later, and three months later to determine temporal variation of organics. Several organics, such as 1,1,1-trichloroethane, were greatly elevated on the first trip but declined sharply on succeeding trips. One (trichloroethylene) increased on the last two trips, indicating a possible contribution of consumer products to indoor air pollutants loadings. A chamber study of common materials (paint, sheetrock, wallpaper, carpet, glue, cleansers, and insecticide) identified nearly all the target toxic chemicals in emissions from these materials.

6. *Special Study I—Dry Cleaners*		*Pellizzari, 1984*	*29*

The TEAM methodology was tested on a group of potentially highly exposed persons, dry cleaning workers, to determine relationships between air, blood and breath levels at work and at home. Eight workers in three dry cleaning shops (one using 1,1,1-trichloroethane, the second tetrachloroethylene, and the third a mixture of tetrachloroethylene and Stoddard solvent (a hydrocarbon mixture)) were monitored using personal air monitors and fixed monitors indoors and out at home and at work. Levels of 20-25 mg/m^3 tetrachloroethylene were observed in both air and breath. A long biological half-life for tetrachloroethylene was indicated by the fact that weekend values did not decrease.

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Table 1. (continued)

Name and Description of Study	Time of Study	References	Ref. No.
7. Special Study II—Swimming Pools		Unpublished	
Because of suspicions that swimmers might be exposed to chloroform, the TEAM methods were applied to eight life-guards at one indoor and two outdoor swimming pools. Air, water, and breath samples were taken at the pools and at home. Data analysis has not yet been made available.			
8. Special Study III—Mother's Milk		Sheldon, 1985b	28
A study of nursing mothers was made to determine levels of volatile organics and pesticides/PCBs in mother's milk and relationships between exposure in air and body burden in blood, breath, and urine. Seventeen mothers were selected to represent an estimated population of 324 nursing mothers in Bayonne and Elizabeth, NJ as part of the TEAM Phase II Study. Many volatile organics and pesticides/PCBs were identified in milk samples. Nursing mothers exhaled relatively smaller amounts of volatile organics in breath, indicating a possible increased bioconcentration in fat compared to nonnursing mothers.			
9. Special Study IV—"Washout" Study		Gordon, 1988	21
To establish effective biological half-lives in blood and breath of the TEAM target volatiles at normal environmental levels, four persons remained in a room-sized pure air chamber at IIT Research Institute for 10 hours, allowing 18 breath samples to be collected. Half-lives of a few hours (benzene) to 21 hours (tetrachloroethylene) were established.			

Table 2. Sites Visited in the Main TEAM Study.

Site Visit Code	Location	Time of Visit	No. of Respondents	Population Represented
NJ1	Bayonne & Elizabeth, NJ	Sept.-Nov. 1981	355	128,000
NJ2	Bayonne & Elizabeth, NJ	July-Aug. 1982	157[a]	109,000
NJ3	Bayonne & Elizabeth, NJ	Jan.-Feb. 1983	49[a]	94,000
NCC	Greensboro, NC	May 1982	24	131,000
ND	Devils Lake, ND	Oct. 1982	24	7,900
LA1	Los Angeles, CA	Feb. 1984	117	360,000
LA2	Los Angeles, CA	May 1984	52[c]	333,000
CC	Antioch & Pittsburg, CA (Contra Costa County)	June 1984	71	91,000
Total	7 cities		591	717,000

[a] Subset of NJ1 respondents.
[b] Subset of NJ2 respondents.
[c] Subset of LA1 respondents.

Sources of Exposure

All participants were asked if they had been exposed to potential sources of target chemicals on the day they were monitored or within the previous week. Sources included industrial plants, auto exhaust, and paint. For 10 of the 12 sources, at least one (and as many as six) of the 11 most prevalent chemicals appeared at significantly higher levels in the breath of persons exposed during the day or week compared to those not exposed to the source. In most cases, the chemicals that were elevated were those expected to be associated with a given source, such as tetrachloroethylene with dry cleaners and benzene with service stations or with auto exhaust.

A second series of questions concerned direct exposure to chemical groups or mixtures. These chemical mixtures included solvents, pesticides, and tobacco smoke. Again, certain chemicals appeared at significantly higher levels in the breath of exposed persons compared to those not exposed. Table 7 summarizes the chemicals with signficantly elevated breath and personal air concentrations in people exposed to potential sources.

Relationship of Benzene and Other Aromatics to Smoking

Benzene concentrations in air and breath were significantly different for smokers and non-smokers. Median daytime air exposures in the fall of 1981 were 21 $\mu g/m^3$ for smokers, and 12 $\mu g/m^3$ for non-smokers. Breath medians were 22 $\mu g/m^3$ for smokers, 7.9 $\mu g/m^3$ for non-smokers.

Three other aromatics (*p*-xylene, ethylbenzene, and styrene) also showed significantly elevated levels in the breath of smokers compared to non-smokers during all three seasons. (The fifth aromatic, *o*-xylene, was elevated but usually not significantly.) Two laboratory studies have identified these five aromatic components in sidestream smoke (3) and mainstream smoke (4).

Smokers generally had 2-4 times as much benzene in their breath as non-smokers. Also, benzene levels in the homes containing smokers were 30-50% higher than in non-smoking households. Since about 60% of U.S. children live in homes with smokers, it appears possible that a large number of children have increased exposure to benzene, a known leukemogen, during their early years. A recent study by Sandler (5) comparing lifetime cancer mortality rates of persons who were exposed or were not exposed as children to parental smoking showed significant increases in hematopoietic (leukemia, lymphomas, etc.) mortality rates in the exposed group. The odds ratio increased from 1.7 with one parent smoking to 4.6 wih both parents smoking.

Phase III (California)

On the February trip to Los Angeles, mean overnight outdoor air concentrations were greatly elevated by nighttime inversions, and were usually similar to mean personal exposures; however, on the May trip to Los Angeles and the June trip to Antioch-Pittsburg, the personal air exposures again exceeded the outdoor levels (Table 8).

Comparison of New Jersey and California Results

Response Rates. Response rates were similar (43-57%) in the New Jersey and California locations (Table 9), and probably represent the best (using these procedures) that can be achieved in the general population considering the heavy burden of carrying monitoring instruments 24 hours a day.

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Table 3. *Target Compounds Selected for Monitoring in Environmental Media*

Matrix: Personal and Fixed-Site Air

- Chloroform
- 1,1,1-Trichloroethane
- Benzene
- Carbon tetrachloride
- Trichloroethylene
- Tetrachloroethylene
- *n-Decane
- *Dodecane
- *1,4-Dioxane
- *1,1,1,2-Tetrachloroethane
- *α-Pinene
- Chlorobenzene
- Styrene
- o,m,p-Dichlorobenzenes
- Ethylbenzene
- o,m,p-Xylenes
- *Undecane
- *n-Octane
- 1,2-Dichloroethane
- *1,1,2,2-Tetrachloroethene

Matrix: Drinking Water

- Chloroform
- Trichloroethylene
- Dibromochloromethane
- Chlorobenzene
- 1,1,1-Trichloroethane
- Bromodichloromethane
- Tetrachloroethylene
- Bromoform

Matrix: Breath

- Bromodichloromethane
- Dibromochloromethane
- Chloroform
- 1,1,1-Trichloroethane
- Benzene
- Carbon tetrachloride
- Tetrachloroethylene
- *n-Decane
- *Dodecane
- *1,4-Dioxane
- *1,1,1,2-Tetrachloroethane
- Bromoform
- Chlorobenzene
- Styrene
- o,m,p-Dichlorobenzene
- Ethylbenzene
- o,m,p-Xylenes
- Trichloroethylene
- 1,2-Dibromoethane
- *n-Octane
- *Undecane
- 1,2-Dichloroethane
- *1,1,2,2-Tetrachloroethane
- *α-Pinene

*California only.

Concentrations. For indoor air, no obvious differences between New Jersey and California appear. However, for outdoor air, the February overnight concentrations in Los Angeles stand out—six chemicals (benzene, 1,1,1-trichloroethane, tetrachloroethylene, *p*-xylene, *o*-xylene, and ethylbenzene) exceed the highest New Jersey values by a factor of 2 or more, whether medians or 90th percentile concentrations are compared. In both California and New Jersey maximum indoor concentrations usually far exceeded maximum outdoor concentrations measured at the same homes (Table 10).

The observation in New Jersey of significant correlations between breath and air concentrations of most of the prevalent chemicals was repeated in the California visits.

TEAM Study Publications

A number of EPA reports and journal articles have been published on various aspects of the TEAM Study. All of these publications are listed in Table 11.

Summary and Conclusions

The major findings of the TEAM Study may be summarized as follows:

1. Measurement of personal exposures using the Tenax personal monitors was shown to be a feasible approach, acceptable to essentially all subjects (ages 7

Table 4. *Estimates of Air and Breath Concentrations of 11 Prevalent Compounds for 130,000 Elizabeth-Bayonne Residents (Fall 1981); 110,000 Residents (Summer 1982); and 49,000 Residents (Winter 1983)*

	Season I (Fall)			Season II (Summer)			Season III (Winter)		
	Personal Air (N=340)	Outdoor Air (86)	Breath (300)	Personal Air (150)	Outdoor Air (60)	Breath (110)	Personal Air (49)	Outdoor Air (9)	Breath (49)
1,1,1-Trichloroethane	94[a]	7.0[a]	15[a]	67	12	15	46	1.7	4.0
m,p,-Dichlorobenzene	46	1.7	8.1	50	1.3	6.3	71	1.2	6.2
m,p-Xylene	52	11	9.0	37	10	10	36	9.4	4.7
Tetrachloroethylene	45	6.0	13	11	6.2	10	28	4.2	11
Benzene	28	9.1	19	NC[c]	NC	NC	NC	NC	NC
Ethylbenzene	19	4.0	4.6	9.2	3.2	4.7	12	3.8	2.1
o-Xylene	16	4.0	3.4	12	3.6	5.4	13	3.6	1.6
Trichloroethylene	13	2.2	1.8	6.3	7.8	5.9	4.6	0.4	0.6
Chloroform	8.0	1.4	3.1	4.3	13	6.3	4.0	0.3	0.3
Styrene	8.9	0.9	1.2	2.1	0.7	1.6	2.4	0.7	0.7
Carbon tetrachloride	9.3	1.1	1.3	1.0	1.0	0.4	ND[d]	ND	ND
Total (11 compounds)	338	48	80	200	59	66	216	25	31

[a]Average of arithmetic means of day and night 12-hour samples (μg/m³).
[b]Arithmetic mean.
[c]Not calculated—high background contamination.
[d]Not detected in most samples.

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to 85), and capable of detecting exposures to most of the target compounds at normal environmental concentrations.

2. Measurement of exhaled breath proved to be a sensitive and non-invasive way to determine body burden.

3. Mean personal air exposures to essentially every one of the 11 prevalent target chemicals were greater than mean outdoor concentrations at 7 of 8 locations/monitoring periods. (The one exception was Los Angeles in February, where strong overnight inversions led to elevated outdoor concentrations.) The upper 10% of personal exposures always exceeded the upper 10% of outdoor concentrations for all sites and time periods.

4. A major reason for these higher personal exposures appears to be elevated indoor air levels at work and at home.

5. The elevated indoor air levels appear to be due to a variety of sources, including consumer products, building materials, and personal activities.

6. The breath levels correlated significantly with personal air exposures to nearly all chemicals but did *not* correlate with outdoor air levels. This is further corroboration of the relative importance of indoor air compared with outddor air.

7. A number of specific sources of exposure were identified including:

   a. Smoking (benzene, xylenes, ethylbenzene, styrene in breath)

   b. Passive smoking (same chemicals in indoor air)

   c. Visiting dry cleaners (tetrachloroethylene in breath).

   d. Visiting a service station (benzene in breath)

   e. Various occupations, including: chemicals, plastics, wood pro-

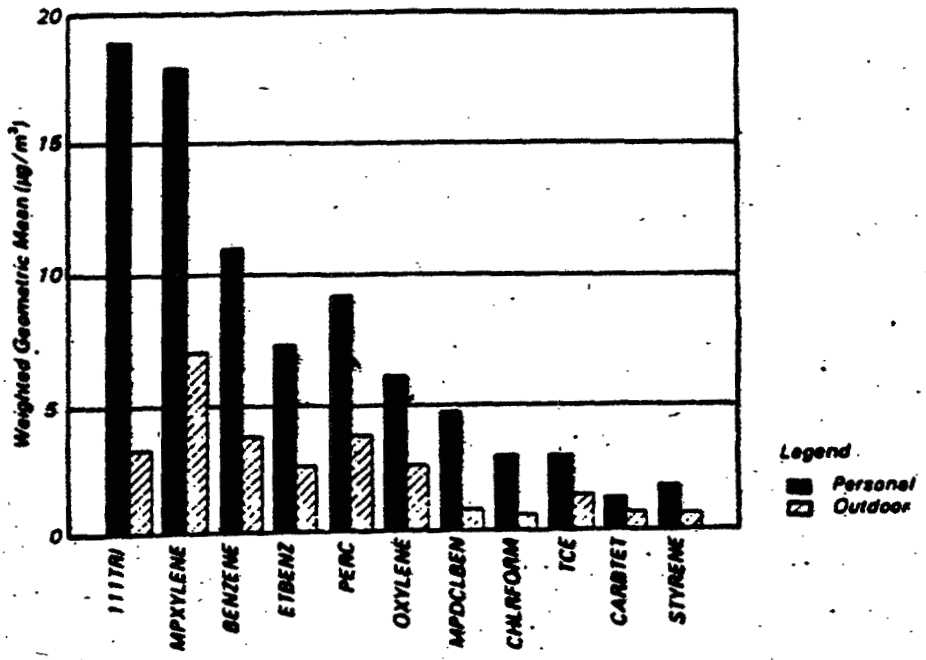

Figure 1. Estimated geometric means of 11 toxic compounds in daytime (6:00 am to 6:00 pm) air samples for the target population (128,000) of Elizabeth and Bayonne, New Jersey, between September and November 1981. Personal air estimates based on 340 samples; outdoor air estimates based on 88 samples.

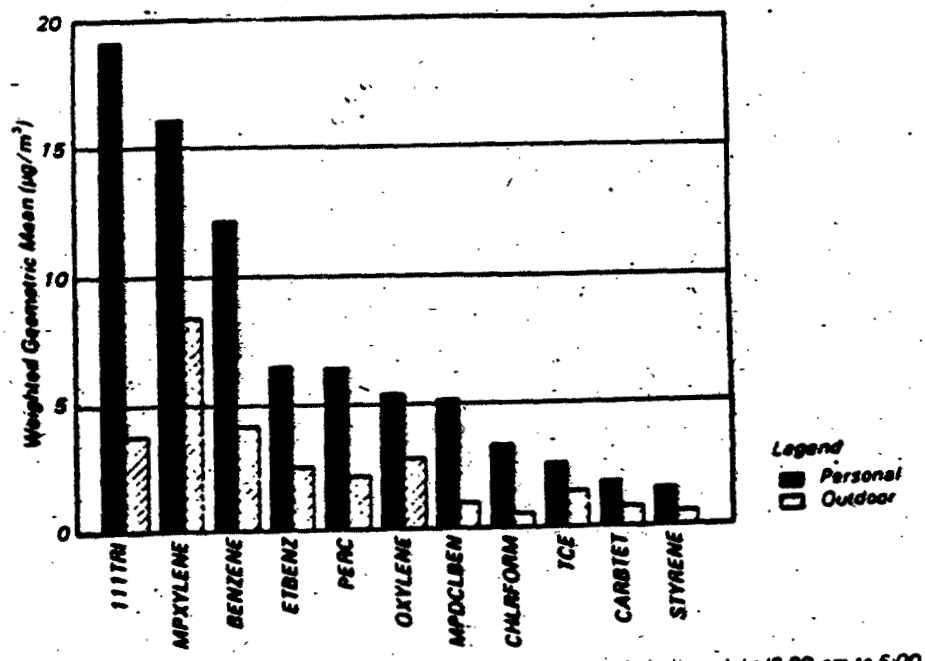

Figure 2. Estimated geometric means of 11 toxic compounds in overnight (6:00 pm to 6:00 am) air samples for the target population (128,000) of Elizabeth and Bayonne, New Jersey, between September and November 1981. Personal air (i.e., indoor) estimates based on 347 samples; outdoor air estimates based on 84 samples.

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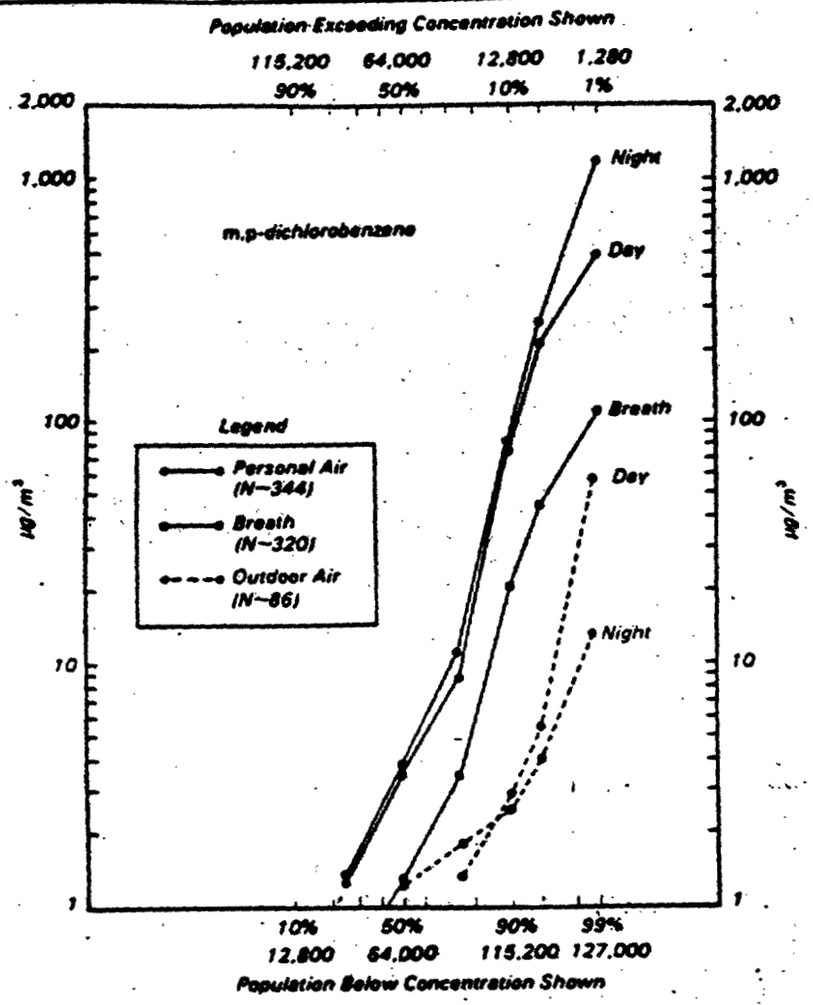

Figure 3. *m,p-Dichlorobenzene: Estimated frequency distributions of personal air exposures, outdoor air concentrations, and exhaled breath values for the combined Elizabeth-Bayonne, target population (128,000). All air values are 12-hour integrated samples. The breath value was taken following the daytime air sample (6:00 am to 6:00 pm). All outdoor samples were taken in the vicinity of the participants' homes.*

cessing, scientific laboratories, garage or repair work, metal work, printing, etc. (mostly aromatic chemicals in daytime personal air)

8. Other sources were hypothesized, including:
   a. Hot showers (chloroform in indoor air)
   b. Room air fresheners or moth crystals (*p*-dichlorobenzene in indoor air)
9. In most cases, these sources far outweighed the impact of traditional "major" point sources (chemical plants, petroleum refineries, petrochemical plants) and area sources (dry cleaners and service stations) on personal exposure.
10. For all chemicals, except the trihalomethanes, the air route provided >99% of the exposure. Water provided nearly all of the exposure to the three brominated trihalomethanes, and more than half of most personal exposures to chloroform.

Recommendations

The major findings of this study is the observation that personal exposures to these toxic and carcinogenic chemicals are nearly always greater—often much greater—than outdoor concentrations. We are led to the conclusion that indoor air in the home and at work far outweighs outdoor air as a route of exposure to these chemicals.

Until now federal and state regulators and directors of research have focused most of their attention on sources affecting outdoor concentrations. Therefore, it is important to verify the findings of the TEAM Study and, if true, incorporate them into future research and regulatory strategies.

An appropriate next step would be to investigate the sources of these exposures more systematically than was possible in the TEAM Study. The relative contribution of building materials, furnishings, personal activities, and consumer products to personal exposures should be determined by intensive studies in a number of homes, office buildings, schools, and other structures where people spend much of their time. In particular, the following specific recommendations are made:

1. *Extend studies of human exposure to other cities and rural areas.* The studies in Greensboro, North Carolina and Devils Lake, North Dakota were too small to provide much stability to their estimates of human exposure. Thus, additional studies of medium-sized cities and rural areas are needed. Also, the larger studies in Elizabeth, Bayonne, Los Angeles, Antioch, and Pittsburg all took place in areas of intensive chemical manufacturing and petroleum refining. Future studies should include large cities without such sources to determine the applicability of TEAM findings to the types of locations in which most people in the U.S. live.
2. *Follow up previous studies to determine the reasons for elevated exposures.* By using the persons (or homes) already mea-

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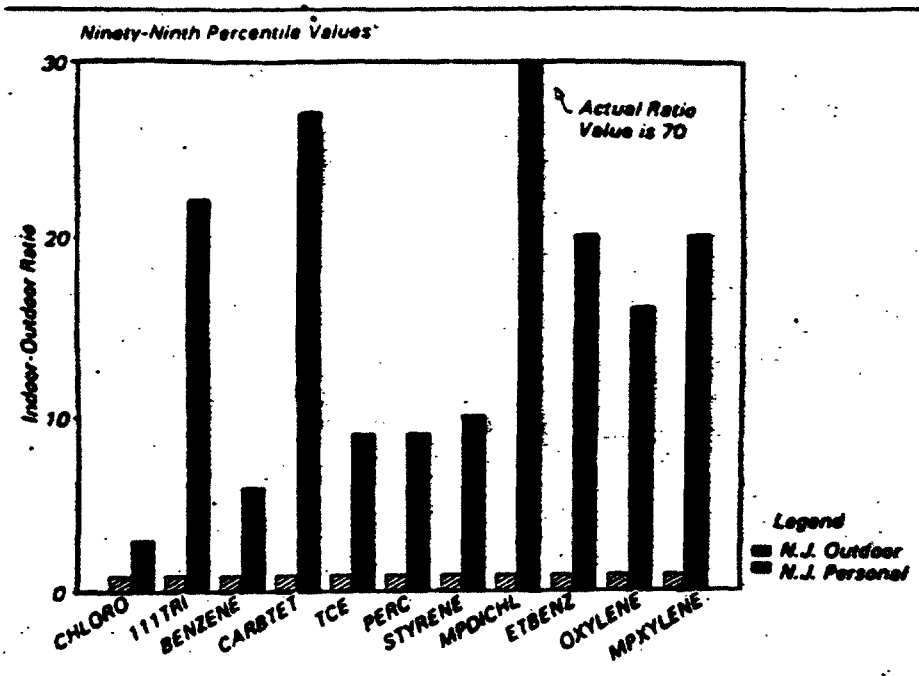

Figure 4. Comparison of unweighted 99th percentile concentrations of 11 prevalent chemicals in overnight outdoor air and overnight personal air in New Jersey (Fall 1981).

Table 5. Arithmetic Means and Maxima (µg/L) of Organic Compounds in New Jersey Drinking Water

	Fall 1981 (128,000)[a]		Summer 1982 (109,000)[b]		Winter 1983 (94,000)[c]	
Chemical	Mean	Max	Mean	Max	Mean	Max
Chloroform	70	170	61	130	17	33
Bromodichloromethane	14	23	14	54	5.4	16
Dibromochloromethane	2.4	8.4	2.1	7.2	1.4	3
1,1,1-Trichloroethane	0.6	5.3	0.2	2.6	0.2	1.6
Trichloroethylene	0.6	4.2	0.4	8.3	0.4	3.4
Tetrachloroethylene	0.4	3.3	0.4	9.3	0.4	5.0
Toluene	0.4	2.7	-	-	--	-
Vinylidene chloride	0.2	2.4	0.1	2.8	0.2	0.9
Benzene	-	-	0.7	4.8	-	-

[a,b,c] Population of Bayonne and Elizabeth to which estimates apply.

sured, high-exposure persons (homes) that represent known numbers of other persons (homes) can be selected without an expensive screening process.

3. *Perform special studies to determine the strength of hypothesized sources.* These may include experimental studies in occupied houses or emission studies in chambers.

4. *Develop emission inventories of major sources of indoor and personal exposure.* These should emphasize consumer products, building materials, and personal activities such as smoking, filling gas tanks, showering, visiting dry cleaners, etc.

5. *Develop models capable of combining emissions from indoor sources, personal activity patterns, outdoor concentrations, and air exchange rates to predict exposures for large populations.*

The second major finding has been the great utility of breath sampling to estimate levels in the body due to normal daily exposure to toxic chemicals. Breath sampling is non-invasive and is much more sensitive and less costly and difficult than blood sampling. In this study, breath sampling alone was effective in distinguishing between populations exposed to specific sources and those not so exposed. The technique should be investigated for possible use in the following situations:

6. *Estimate dosages of persons exposed to chemical spills or releases.*

7. *Survey healthy persons to establish normal baselines and ranges of biological variability.*

8. *Study diseased persons to establish possible early diagnostic procedures.*

9. *Study acute health effects associated with organic emissions ("sick building syndrome") to determine the extent of the loss of productivity of U.S. workers due to degraded indoor air quality in the workplace.*

A third finding has been the demonstration of the utility of this personal monitoring approach not only in estimating the exposure of entire urban area populations, but also in gaining an understanding of the sources of exposure. The general methodology appears applicable for determining exposures to many other pollutants (e.g., pesticides and metals) provided adequate sampling and analysis protocols for individually-cooked meals can be developed. With the development of better instruments, it should also be possible to carry out large-scale studies of exposure to inhalable particulates and NO_2 in the near future.

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Table 6. Spearman Correlations Between Breath Concentrations and Preceding Daytime 12-Hour Personal Exposures to Eleven Compounds in New Jersey, North Carolina, and North Dakota

	NJ1[a] (N=330)	NJ2[b] (N=130)	NJ3[c] (N=47)	ND[d] (N=23)	NC[e] (N=23)
Chloroform	.07	-.11	-.03	-.01	.46*
1,1,1-Trichloroethane	.28*	.26*	.32*	.71*	-
Benzene	.21*	-[f]	-	-	.22
Carbon tetrachloride	.24*	-.01	-	-.23	-.53*
Trichloroethylene	.38*	.10	.36*	.26	.38
Tetrachloroethylene	.46*	.23*	.37*	.53*	.58*
Styrene	.19*	.20*	.19	-	.32
m,p-Dichlorobenzene	.54*	.38*	.61*	.63*	.68*
Ethylbenzene	.33*	.22*	.44*	.12	-.01
o-Xylene	.26*	.22*	.45*	.21	.28
m,p-Xylene	.32*	.27*	.48*	.19	.08

[a]Fall 1981.
[b]Summer 1982.
[c]Winter 1983.
[d]Fall 1982.
[e]Spring 1982.
[f]Data uncertain based on quality assurance results.
*Significant at $p < .05$ level.

Control of Toxic Emissions

Reduction of exposure to the toxic chemicals measured in the TEAM Study may come about through two types of action: individual and organizational.

Individual Actions. Several of the sources identified in the TEAM Study may be dealt with by simple means. For example, unused paint cans, aerosol sprays, cleansers, solvents, etc., may be disposed of or stored in a detached garage or tool shed. Charcoal filters attached to the kitchen and bathroom taps can remove chloroform and other trihalomethanes from water supplies. (However, some filters are relatively ineffective; an EPA study and a *Consumers Report* article have identified effective and ineffective brands.) Discontinuing use of room air fresheners or switching to brands that do not contain *p*-dichlorobenzene will reduce exposure to that chemical. Discontinuing smoking, smoking only outdoors or in well-ventilated rooms, or installing air cleaners can reduce involuntary smoking by children or spouses. Dry-cleaned clothes could be aired out for a few hours on a balcony or porch before hanging them in a closet.

Organizational Actions. As in the case of formaldehyde, manufacturers may reduce toxic emissions from their products, either by modifying manufacturing processes or substituting less toxic chemicals. Voluntary building standards may be adopted, limiting emissions for building materials. Local, state, or federal governments could adopt a variety of legislative solutions, such as the various laws restricting smoking in public buildings.

Associations such as the Air Pollution Control Association, the American Lung Association, the Association for Standards and Testing of Materials, the Consumer Federation of America, the National Institute for Building Sciences, the American Institute of Architects, and others have in recent years recognized the importance of indoor air pollution and have programs designed to encourage research, communicate research results, establish standards, and/or develop control techniques.

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Table 7. *Chemicals with Significantly ($p < .05$) Higher Concentrations in Air and Breath of Persons Recently Exposed to Potential Sources Compared to Persons Not Exposed to Any Source*

Potential Source	No. of Persons Exposed	Ratio of Mean Concentrations: Exposed vs Unexposed Groups	
		Breath	Air
Paint	28		
Benzene		2.3 (.0002)[a]	1.3 (.03)
Tetrachloroethylene		2.0 (.0000)	2.7 (.02)
Styrene		2.8 (.0004)	1.8 (.0006)
Ethylbenzene		1.9 (.0004)	2.1 (.0001)
o-Xylene		1.4 (.009)	2.5 (.0003)
m,p-Xylene		1.7 (.002)	2.6 (.0000)
Chemical Plant	21		
Styrene		1.9 (.02)	2.0 (.004)
Ethylbenzene		2.5 (.0008)	1.8 (.0006)
o-Xylene		1.4 (.06)	2.3 (.0003)
m,p-Xylene		1.9 (.004)	1.9 (.0006)
Plastics Manufacturing	11		
Styrene		2.0 (.01)	2.6 (.02)
Ethylbenzene		2.8 (.003)	1.8 (.03)
o-Xylene		3.4 (.0006)	2.3 (.02)
m,p-Xylene		2.5 (.001)	2.1 (.02)
Dry Cleaning	37		
Tetrachloroethylene		2.3 (.0000)	2.2 (.003)
Benzene		2.2 (.02)	1.7 (.03)
Petroleum Plant	19		
None			
Service Station	67		
Benzene		2.2 (.0000)	1.3 (.02)
Printing	9		
Ethylbenzene		1.8 (.02)	1.6 (.03)
o-Xylene		1.3 (.03)	2.2 (.02)
Metal Working	17		
Tetrachloroethylene		1.4 (.01)	1.8 (.03)
Ethylbenzene		1.8 (.05)	3.7 (.0000)
o-Xylene		1.8 (.05)	4.4 (.0000)
Science Laboratory	14		
Ethylbenzene		1.7 (.03)	2.2 (.002)
o-Xylene		1.4 (.05)	2.7 (.001)
Furniture Refinishing	7		
Ethylbenzene		2.8 (.03)	2.2 (.02)
o-Xylene		2.5 (.04)	2.4 (.006)
Hospital	13		
None			

[a] Probability of no difference between exposed and unexposed groups—Wilcoxon Rank-Sum Test

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ble 8. *Estimates of Air and Breath Concentrations of Nineteen Prevalent Compounds for 360,000 Los Angeles Residents (February 1984), 330,000 Los Angeles Residents (May 1984), and 91,000 Contra Costa Residents (June 1984)*

	LA1			LA2			CC		
	Personal Air (N=110)	Outdoor Air (24)	Breath (110)	Personal Air (50)	Outdoor Air (23)	Breath (50)	Personal Air (67)	Outdoor Air (10)	Breath (67)
1,1,1-Trichloroethane	96[a]	34[a]	39[b]	44	5.9	23	16	2.8	16[b]
m,p-Xylene	28	24	3.5	24	9.4	2.8	11	2.2	2.5
m,p-Dichlorobenzene	18	2.2	5.0	12	0.8	2.9	5.5	0.3	3.7
Benzene	18	16	8.0	9.2	3.6	6.8	7.5	1.9	7.0
Tetrachloroethylene	16	10	12	15	2.0	9.1	5.6	0.6	8.6[b]
o-Xylene	13	11	1.0	7.2	2.7	0.7	4.4	0.7	0.6
Ethylbenzene	11	9.7	1.5	7.4	3.0	1.1	3.7	0.9	1.2
Trichloroethylene	7.6	0.8	1.6	6.4	0.1	1.0	3.8	0.1	0.6
n-Octane	5.8	3.9	1.0	4.3	0.7	1.2	2.3	0.5	0.6
n-Decane	5.8	3.0	0.8	3.5	0.7	0.8	2.0	3.8	1.3
n-Undecane	5.2	2.2	0.6	4.2	1.0	0.7	2.7	0.4	1.2
n-Dodecane	2.5	0.7	0.2	2.1	0.7	0.4	2.1	0.2	0.4
α-Pinene	4.1	0.8	1.5	6.5	0.5	1.7	2.1	0.1	1.3
Styrene	3.6	3.8	0.9	1.8	—	—	1.0	0.4	0.7
Chloroform	1.9	0.7	0.6	1.1	0.3	0.8	0.6	0.3	0.4
Carbon tetrachloride	1.0	0.6	0.2	0.8	0.7	0.2	1.3	0.4	0.2
1,2-Dichloroethane	0.5	0.2	0.1	0.1	0.06	0.06	0.1	0.05	0.04
p-Dioxane	0.5	0.4	0.2	1.8	0.2	0.05	0.2	0.1	0.2
o-Diochlorobenzene	0.4	0.2	0.1	0.3	0.1	0.04	0.6	0.07	0.08
Total (19 compounds)	240	120	80	150	33	56	72	16	62

[a]Average of arithmetic means of day and night 12-hour samples ($\mu g/m^3$).
[b]One very high value removed.

Table 9. Comparison of New Jersey and California Response Rates

	New Jersey		California	
	Bayonne	Elizabeth	Los Angeles	Antioch/ Pittsburg
Households screened	2204	3374	1260	604
Eligible households	2063	3146	1219	561
Screening completed	1788	2638	1063	502
Completion rate	87%	84%	87%	89%
Eligible persons	281	396	190	121
Completed study	154	201	117	71
Completion rate	55%	51%	62%	59%
Overall Response Rate	48%	43%	54%	53%

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Table 10. Maximum Overnight Concentrations Indoors and Outdoors for Homes with Outdoor Monitors: TEAM Study, 1981-84

	New Jersey						California					
							Los Angeles				Contra Costa	
	Sept.-Nov. 1981 (N=65)		July-Aug. 1982 (N=71)		Feb. 1983 (N=8)		Feb. 1984 (N=25)		May 1984 (N=25)		June 1984 (N=10)	
	In	Out	In	Out	In	Out	In	Out	In	Out	In	Out
m,p-Dichlorobenzene	920	13	1600	8	120	5	210	21	170	2	8	1
1,1,1-Trichloroethane	880	40	120	61	170	10	200	190	94	20	14	10
Tetrachloroethylene	250	27	98	26	72	5	96	34	58	5	9	6
Benzene	120	91	NC[a]	NC	NC	NC	43	33	29	8	22	4
m,p-Xylene	120	70	150	68	63	14	58	52	94	26	26	4
Ethylbenzene	320	20	180	28	32	5	29	26	35	13	9	2
o-Xylene	46	27	100	31	24	5	34	28	29	6	11	2
Chloroform	220	22	35	130	16	1	6	6	20	2	6	2
Trichloroethylene	47	15	59	61	7	0.7	50	3	11	2	4	0.3
Styrene	54	11	10	11	11	1	9	9	5	3	4	2
Carbon tetrachloride	14	14	6	5	NC	NC	3	2	1	1	3	2
Octane	-[b]	-	-	-	-	-	38	12	20	2	2	2
Decane	-	-	-	-	-	-	11	27	17	2	26	7
Undecane	-	-	-	-	-	-	11	19	76	6	16	2
Dodecane	-	-	-	-	-	-	10	4	57	3	5	1
α-Pinene	-	-	-	-	-	-	44	5	29	2	3	1
1,4-Dioxane	-	-	-	-	-	-	4	5	4	2	1	1

[a]Not calculated.
[b]Not measured.

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Table 11. TEAM Study Publications

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The complete report consists of four volumes, entitled "The Total Exposure Assessment Methodology (TEAM) Study." (Set Order No. PB 88-100 052; Cost: $151.00)

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